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	Subsystem/Office Calorimeter Subsystem	
Document Title Report on First Crystal Delivery from Amcrs H		

1 Summary

On May 1 we received 13 CsI crystals from Amcrs in Ukraine. On June 1 we received another 11 crystals. Four of these crystals have been sent to NRL in Washington and have not been subject to any formal testing in Kalmar. This report is a short account for the tests performed on the remaining 20 crystals. All details about the optical test results are stored in the data files on the CD enclosed this report.

Each crystal comes wrapped in white Tyvak (diffuser) plus aluminum foil. At the center of one of the largest surfaces there is a label with the crystal's serial number (s/n). Holding the crystal in front of oneself with the label facing upwards and so that the serial number can be read in a normal way defines "left" and "right" ends of the crystal as well as "top" and "bottom" surfaces. This orientation also defines the "standard orientation" in which testing is carried out. For the optical tests the crystals are placed with their left end towards the left PM-tube in the test box and the top surface (with the label) facing upwards. In this way the s/n label is easily read also when the crystal is in its test position in the test box.

2 Measurements of Mechanical Dimensions

The mechanical dimensions of the 20 crystals left after four had been sent to NRL (cf. table 1) have been measured according to the following procedure. Firstly, the crystal was placed in standard orientation on a flat reference table. Its top surface was measured at six points: two points at each end and two at the middle. The two points at each end of the crystal were 20 mm from the end edge and 2 mm from each long edge, respectively. The points at the middle were also 2 mm from the long edges. Secondly, the crystal was rotated 90° azimuthally so that the s/n label was facing towards the operator instead of upwards. The surface now facing upwards was measured at six points in the same way as the first surface was. Thirdly, the length of the crystal was measured at five points: at each corner (2 mm from edges) plus at the center of the end surfaces.

The equipment used for measuring the mechanical dimensions of the crystals was thoroughly calibrated against three gauge blocks (19.7 mm, 26.5 mm and 100.0 mm) traceable to the Swedish National Standard. Every time there was an indication of a reading not consistent with specifications, the calibration of the equipment was checked against the gauge blocks. It was always found to be within 0.01mm from the reference value. The contact probe chosen for surface measurements was a wheel with 5mm radius in order to be insensitive to small variations in the surface on scale of scratches from grinding. The shanks for measuring lengths have infinite radius, which was adequate since all end surfaces were slightly convex.

The results of the mechanical measurement are presented in the appendix. The crystals are listed in the same order as they were measured. The six readings for the firstly and secondly measured surfaces (as described above) are presented in the same configuration as the measurement points. Only the largest obtained value for the measurement of the crystal length is presented. This was for all crystals the distance between the center points of the end surfaces. All values are given in mm unless else is specified. Also noted are the weight (in g), temperature (in °C) and relative humidity (in %). According to the crystal specification document mechanical dimensions should be measured at 20° C. The numbers given in the appendix have not been corrected for this. Prior to these measurements the crystals had been stored more than 24 h under the following conditions: 22° C and 40–43% RH.

All 20 crystals appeared to have a slight “barrel shape”, i.e. most surfaces was found to be slightly convex (possibly a result from the polishing process). Also the end surfaces are slightly convex, within 0.1 mm (mind mounting of PIN-diodes). Many crystals were slightly too long (<0.1 mm). Some might fit within spec's at 20° C but not all.

3 Optical Tests

Out of the 20 tested crystals, one crystal (s/n 32K4-3-3) failed to meet the specification: tapering of light output was inadequate. A visual inspection of the crystal surfaces indicated that too little grinding could be the reason. Another crystal (s/n 32K4-4-1) has a ~3 mm long scratch mark at one of its edges at the left end. Yet four other crystals (s/n 167P3-4-2, 167P3-4-13, 167P3-40-2 and 170P3-40-8) contain small fragments (~0.5 mm) unevenly scattered throughout their volumes. These impurities seem to have no effect on the crystal's optical performance. The remaining crystals were tested without remark. All 24 crystals of this first delivery from Amcrys are listed in table 1.

Table 1: first 24 crystals delivered from Amcrys, Ukraine.

Number	Serial No.	Remarks
1	32K4-2-1	good: shipped to Paris
2	32K4-2-2	good: shipped to Paris
3	32K4-2-4	good: shipped to Paris
4	32K4-2-7	good: shipped to Paris
5	32K4-3-1	good: shipped to Paris
6	32K4-3-3	failed optical specifications
7	32K4-3-4	shipped to NRL
8	32K4-3-8	good: shipped to Paris
9	32K4-4-1	minor scratch mark at left end edge; shipped to Paris
10	32K4-4-2	good: shipped to Paris
11	32K4-4-3	shipped to NRL
12	32K4-4-4	over the mechanical tolerances
13	32K4-4-5	good: shipped to Paris
14	32K4-4-6	good: shipped to Paris
15	32K4-4-8	good: shipped to Paris
16	32K4-5-1	good: shipped to Paris
17	32K4-5-2	shipped to NRL
18	32K4-5-5	good: shipped to Paris
19	32K4-6-1	shipped to NRL
20	32K4-6-3	good: shipped to Paris
21	167P3-4-2	impurities
22	167P3-4-13	impurities: shipped to Paris

23	167P3-40-2	impurities: shipped to Paris
24	170P3-40-8	impurities

3.1 Tapering of Light Output

The decrease in light output observed when the ^{22}Na source is moved away from the PM-tube has been measured in the standard way as described in the crystal specification document. The end positions of the source were at 31 mm and 32 mm from the left and right end of the crystal, respectively^{*)}. With the source located at one of the end positions, we use the average signal sizes from each PM-tube to form a ratio of the smaller PM-tube signal to the larger. There are two ratios for each end positioning of the source. These ratios are listed in table 2 for the 20 crystals tested.

Table 2: Far-to-close-PM ratios for the 20 tested crystals. “Left position” and “right position” refer to the cases when the source is located at the crystal’s left and right end, respectively.

Crystal S/N	Left Position	Right Position	Remark
32K4-2-1	61 %	57 %	shipped to Paris
32K4-2-2	68 %	66 %	shipped to Paris
32K4-2-4	59 %	58 %	shipped to Paris
32K4-2-7	64 %	64 %	shipped to Paris
32K4-3-1	71 %	71 %	shipped to Paris
32K4-3-3	76 %	80 %	
32K4-3-8	67 %	68 %	shipped to Paris
32K4-4-1	66 %	66 %	shipped to Paris
32K4-4-2	65 %	66 %	shipped to Paris
32K4-4-4	57 %	58 %	
32K4-4-5	59 %	60 %	shipped to Paris
32K4-4-6	55 %	58 %	shipped to Paris
32K4-4-8	59 %	59 %	shipped to Paris
32K4-5-1	58 %	62 %	shipped to Paris
32K4-5-5	57 %	56 %	shipped to Paris
32K4-6-3	65 %	65 %	shipped to Paris
167P3-4-2	71 %	72 %	
167P3-4-13	65 %	68 %	shipped to Paris

^{*)} According to the crystal specification document the end positions should be at 20 mm from the closest end of the crystal. The fact that the end positions were not set to this value during the present tests was due to a trivial mistake. Thus, the values in table 2 should in general be about 2 units (%) smaller.

167P3-40-2	60 %	60 %	shipped to Paris
170P3-40-8	63 %	65 %	

3.2 Charge resolution

The data acquisition software fits a gaussian to the peak from 511 keV gammas from the ^{22}Na source. One of the fit parameters is the standard deviation of the gaussian. By taking this number and multiplying it by 2.35 we obtain an estimate for the peak's FWHM. The FWHM divided by the average of the peak lies in the interval between 12% and 19% for all crystals and all source positions. According to the crystal specification document (see paragraphs 6.2.1 and 6.2.2 in LAT Calorimeter CsI Crystal Specification, document # LAT-DS-00095-01) all crystals are within the limits with good margin. In the specification the limit value for the FWHM was put to 13 % for the 1.275 MeV gamma line from the ^{22}Na source. Because we are operating in the photostatistics region, resolution is inversely proportional to the squareroot of the gamma energy. Hence, the limit value corresponds to 21 % at 511 keV.

3.3 Homogeneity of Total Light Output

Summing both PM-tube signals from one and the same gamma event gives a measure of the total light output from the crystal, which should be rather independent of the source's longitudinal position^{*)}. The position (mean value) of the so obtained peak evidently also shows only a weak dependence as a function of the longitudinal source position. Taking the average of the 11 peak positions, we find that the position of any individual peak does not deviate more than 6.5 % from the average. This is true for all 20 crystals of this testing batch.

^{*)} As a side remark it can be mentioned that we apparently have quite a lot of radioactive potassium in the concrete floor and ceiling of our lab. The gamma rays from this ^{40}K strike the crystals at a random position. Thus, the signal is smeared out in the individual PM spectra but forms a pronounced peak in the sum spectrum of both PM-tubes together.

APPENDIX

Mechanical dimensions of crystals listed in order of measurement. The crystals s/n is written in font 16 and bold face. Surface readings are presented in the same configuration as the measuring points. "H" refers to the top surface and "W" to one of the side surfaces (see the main text for further details). "L=" means the crystal length and "W=" the crystal weight. If a value does not meet the specifications it is highlighted in bold face.

32K4-3-3

H

19.70 19.78 19.73

19.69 19.78 19.72

W

26.54 26.61 26.56

26.56 26.66 26.61

L=332.9

Wt=790g

22degC

43% RH

Twist and bending less than 0.1mm

32K4-3-1

H

19.81 19.84 19.81

19.77 19.80 19.78

W

26.54 26.59 26.56

26.58 26.65 26.62

L=332.79

Wt=791g

22degC

43% RH

Small marks after machining.

167P3-40-2

H

19.75 19.79 19.73

19.70 19.73 19.65

W

26.64 26.70 26.60

26.61 26.66 26.55

L=332.85

Wt=790g

22degC

43% RH

Small particles, most in right end. Small polish marks in left corner

167P3-4-13

H

19.69 19.77 19.73

19.71 19.77 19.74

W

26.56 26.62 26.60

26.52 26.59 26.56

L=332.96

Wt=790g

22degC

42% RH

Small particles in left end.

170P3-40-8

H

19.59 19.67 19.58

19.55 19.63 19.56

W

26.58 26.61 26.56

26.52 26.57 26.52

L=333.05*

Wt=783g

22degC

43% RH

*Out of spec.

32K4-4-6

H

19.79 19.85 19.83

19.78 19.85 19.85

W

26.66 26.67 26.66

26.67 26.69 26.68

L=333.05*

W=796g

23degC

43% RH

*Out of spec.

32K4-4-1

H

19.73	19.77	19.75
-------	-------	-------

19.69	19.71	19.71
-------	-------	-------

W

26.60	26.60	26.59
-------	-------	-------

26.64	26.62	26.63
-------	-------	-------

L=332.99

Wt=791g

23degC

43% RH

32K4-4-2

H

19.75	19.78	19.77
-------	-------	-------

19.75	19.79	19.79
-------	-------	-------

W

26.67	26.64	26.59
-------	-------	-------

26.73*	26.72*	26.67
--------	--------	-------

L=332.90

Wt=794g

24degC

42% RH

2 small polished dents on right side edge.

*Out of spec.

32K4-4-4

H

19.81	19.80	19.74
-------	-------	-------

19.80	19.79	19.74
-------	-------	-------

W

26.61	26.61	26.59
-------	-------	-------

26.62	26.63	26.61
-------	-------	-------

L=333.09*

Wt=793g

24degC

43% RH

*Out of spec.

32K4-5-1

H

19.79	19.85	19.86
-------	-------	-------

19.80	19.85	19.86
-------	-------	-------

W

26.65	26.67	26.65
-------	-------	-------

26.66	26.69	26.67
-------	-------	-------

L=333.04*

Wt=796g

24degC

43% RH

*Out of spec.

32K4-3-8

H

19.74	19.73	19.67
-------	-------	-------

19.76	19.77	19.71
-------	-------	-------

W

26.48	26.52	26.55
-------	-------	-------

26.45	26.48	26.50
-------	-------	-------

L=333.00

Wt=788g

24degC

43% RH

32K4-2-2

H

19.86	19.89	19.88
-------	-------	-------

19.84	19.89	19.88
-------	-------	-------

W

26.55	26.63	26.56
-------	-------	-------

26.57	26.66	26.59
-------	-------	-------

L=332.96

Wt=795g

24degC

44% RH

32K4-6-3

H

19.81	19.86	19.86
-------	-------	-------

19.78	19.85	19.83
-------	-------	-------

W

26.64	26.66	26.66
-------	-------	-------

26.65	26.67	26.65
-------	-------	-------

L=332.85

Wt=796g

24degC

45% RH

32K4-5-5

H

19.77 19.83 19.82

19.75 19.82 19.80

W

26.59 26.63 26.58

26.61 26.65 26.61

This plane soft "banana" approx 0.03

L=333.08*

Wt=794g

24degC

45% RH

*Out of spec.

32K4-4-8

H

19.83 19.87 19.85

19.79 19.83 19.82

W

26.67 26.67 26.65

26.63 26.65 26.61

L=332.92

Wt=796g

24degC

43% RH

32K4-2-7

H

19.76 19.78 19.76

19.74 19.78 19.74

Slight "twist" in this plane, less than 0.05

W

26.56 26.59 26.54

26.55 26.56 26.52

Slight "banana" in this plane, less than 0.03

L=333.03*

Wt=791g

24degC

44% RH

*Out of spec.

32K4-2-4

H

19.77 19.82 19.77

19.73 19.79 19.72

W

26.62	26.64	26.64
-------	-------	-------

26.62	26.65	26.62
-------	-------	-------

L=332.99

Wt=793g

24degC

44% RH

32K4-2-1

H

19.63	19.76	19.71
-------	-------	-------

19.63	19.76	19.70
-------	-------	-------

W

26.54	26.71*	26.63
-------	--------	-------

26.56	26.72*	26.63
-------	--------	-------

L=332.91

Wt=791g

24degC

44% RH

*Out of spec.

32K4-4-5

H

19.77	19.80	19.80
-------	-------	-------

19.78	19.80	19.81
-------	-------	-------

W

26.59	26.60	26.61
-------	-------	-------

26.61	26.64	26.65
-------	-------	-------

L=333.02*

Wt=794g

24degC

44% RH

*Out of spec.